

Office of the Lord President of the Council

ADVISORY COUNCIL ON SCIENTIFIC POLICY

COMMITTEE ON SCIENTIFIC MANPOWER

Report
on the Recruitment of Scientists
and Engineers
by the Engineering Industry



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THE MOST HON. THE MARQUESS OF SALISBURY, K.G.
Lord President of the Council

My Lord Marquess,

In its 8th Annual Report, the Advisory Council on Scientific Policy stated that it was examining certain problems affecting recruitment of graduates and apprentices to the engineering industry. I submit herewith a report on this subject by the Council's Committee on Scientific Manpower, under the Chairmanship of Professor S. Zuckerman. The report is endorsed by the Council, which considers it to be of sufficient general interest to merit publication in full.

I am, My Lord,

Your obedient Servant,
(signed) A. R. TODD.

28th September, 1955

ADVISORY COUNCIL ON SCIENTIFIC POLICY COMMITTEE ON SCIENTIFIC MANPOWER

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THE RECRUITMENT OF SCIENTISTS AND ENGINEERS BY THE ENGINEERING INDUSTRY

Introduction

The record of university development over the past decade begins with the publication, in 1946, of the findings and recommendations of a Committee on Scientific Manpower, under the chairmanship of Sir Alan Barlow (Cmd. 6824). The work of this Committee had been inspired by the fact that the war years of 1939-45 had found us grievously short of scientists and other technically trained manpower, and by the knowledge that there had been little, if any, awareness during the pre-war years that such a shortage either existed or was likely to develop. It was obvious that the task of post-war reconstruction and economic rehabilitation would demand an enormous scientific effort, and the Committee's first task was therefore to assess the likely demand for university trained scientists over the period 1946-55, and the capacity of the universities to turn them out. Precise estimates proved impossible, but the Committee felt secure in suggesting that, on the basis of the universities' own estimates of the number of graduates likely to be coming forward, the demand for scientists and technologists by 1955 was likely to be nearly 50 per cent. greater than the supply. It therefore recommended that the immediate aim of the universities, aided by the University Grants Committee, should be to double their existing output of scientists and technologists. This was in fact achieved by 1950. But the demand continues unabated. Any fears there may have been about the possible over-production of scientists and engineers have been completely dispelled by events.

2. The Barlow Committee's recommendations have led to a great expansion of the universities, particularly in science and technology. Special steps have been taken by the present Government to expand higher technological education, and particularly in the different branches of engineering. At the university level this expansion is taking the form, not of new specialised technological institutions, of which there are well-known examples on the Continent and in the U.S.A. and as had been advocated in certain quarters; the Government have decided instead to concentrate the development of higher technology in certain existing universities and colleges where technology already flourishes. Additional grants for this specific purpose have been made available for the three last years of the present university quinquennium, 1954-55, 1955-56 and 1956-57. In addition to this programme at the university level, the Education Departments are pushing ahead with the development of local and regional technical colleges.

3. These changes have meant some differential expansion of university faculties of science and technology, as compared with the humanities. Even so, the expansion of science and technology in the universities does not, in the view of some authorities, go far enough; but to others, and especially to some in industry, the expansion appears to have gone too far. Thus certain sections of the engineering industry seem to take the view that both the expansion of engineering education at the universities, as well as the encouragement of post-graduate research in engineering at the universities, conflict with the real interests of industry. There is particular concern at the danger that any substantial increase in the number of university students of engineering might diminish the number, and lower the quality, of boys available to the industry for training as student apprentices. In order to test

the strength of this view, the Committee on Scientific Manpower sponsored an inquiry to a number of leading firms, mainly in the engineering industry, about the numbers recruited at various stages of education, and about the value which industry attached to the different types of training.

4. The inquiry started early in 1954 with a preliminary investigation of ten large organisations, of which six were in the aircraft industry, three in other types of engineering, and one in the chemical industry. The results of this pilot study showed that the chemical firm differed from the engineering undertakings in that it saw no conflict of interest between the recruitment of graduates and that of student apprentices. Some of the engineering firms however felt strongly that the expansion of university education would have a deleterious effect on the supply of boys available as apprentices, and they also expressed considerable doubt as to the value of post-graduate research in engineering at the universities. The Committee on Scientific Manpower therefore decided to extend the inquiry further within the engineering manufacturing industry, with the object of covering a wider range of firms. This has now been done. The paragraphs which follow describe the results of this inquiry, together with such comments as the Committee feels able to offer.

5. We wish to make it plain that our inquiry covers only one section of British industry. A considerable proportion of each year's graduates in engineering is taken on by organisations other than manufacturing firms in the engineering industry, e.g. the chemical and petroleum industries, as well as by the nationalised industries. In order to trace some of these graduates, we subsequently approached the National Coal Board, the Central Electricity Authority, the Gas Council, and the British Transport Commission. These nationalised industries, which together recruit at present over 200 graduates in science and engineering each year, were unable to answer all our questions since their apprenticeship schemes had not been in operation long enough to enable them to make an assessment of the value of such training. Essentially, therefore, our report is an analysis of views expressed by firms in the engineering manufacturing industry, which were approached directly because of their known interest in the question. It was clear from the start that we were likely to get the most informative replies from large firms, most of which have developed extensive schemes of training and education. Our sample of firms was therefore not a random one, and the replies which we have received are not necessarily representative of the engineering industry as a whole, still less of all employers of professional engineers. But it is worth noting that we have covered an average annual intake of 935 first degree graduates (mainly technologists) during 1951-53, in addition to the 203 recruited by the nationalised industries, at a time when the total of University first degrees in engineering awarded to internal students averaged 2,300 per annum. As a considerable proportion of the latter found jobs outside industry—in the Civil Service, Local Government, teaching and the Atomic Energy Authority—it is clear that our inquiry has covered quite 50 per cent. of the total intake to industry of engineering graduates from the Universities. In addition we have covered an average annual intake of 293 holders of National Diplomas.

Comparative Numbers of Graduates and Apprentices

6. Table I shows the number of graduates, apprentices and other personnel recruited by the firms in the engineering industry which were able to provide

us with these statistics. (A further small number of firms were able to answer our questions in general terms but were unable to provide figures in the form requested.) Further details of recruitment to the different sections of the engineering industry are shown in Table II (annexed). Table III shows the total number of degrees, diplomas and Higher National Certificates in the Universities and technical colleges of Great Britain over the last few years. Extracts from letters from firms in the engineering industry are given in Appendix I, and others from the nationalised industries are given in Appendix II.

TABLE I: RECRUITMENT OF SCIENTISTS AND ENGINEERS BY
50 FIRMS IN THE ENGINEERING MANUFACTURING INDUSTRY:

SUMMARY

Average Annual Intake 1951-53

Graduates in Science and Technology

Higher Degrees	39
First Degrees	935

Graduates in Other Subjects

First Degrees	70
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<i>Holders of National Diplomas</i>	293
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<i>Student Apprentices</i>	1,173
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<i>Trade and Craft Apprentices</i>	4,156
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<i>Other Personnel</i>	490
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Total	7,156
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General Demand for Graduates

7. Firms were asked to state the number of graduates actually recruited each year compared with the number required, and to give reasons for the difference. The total number recruited was some 25 per cent. below the number required, the reason generally being that insufficient applicants were available. In many cases, references to the insufficiency of graduates were qualified by notes about the poor calibre of the applicants; some firms complained of intense competition from rival organisations, including the Civil Service and the Atomic Energy Authority. Two heavy electrical and mechanical engineering firms complained that there were too few graduates in heavy electrical engineering, as men tended to be attracted by subjects such as electronics, aero engines, guided missiles, etc. Firms which manufactured items such as cooking equipment complained of the difficulty of attracting young men to such relatively unglamorous occupations.

8. The general impression gained is that most firms, especially the big ones, look for men possessing both good honours degrees and good personal qualities, and that such men are very scarce. The replies to questionnaires also reveal a fairly widespread feeling that the quality of graduates has already suffered from the rapid post-war expansion of the Universities, which is assumed to have resulted in some boys of lower academic ability becoming graduates, and also that the proportion of those who live "In Hall", and who therefore profit most from the essential broadening influence of

University life, has been reduced. A great many firms remarked that far too few of the engineering graduates possessed real qualities of leadership, and it was suggested that the full benefits of technological training would only be realised if attention was also paid to general education and the development of character.

9. The Committee was impressed by the fact that the firms which were approached and which, it must be remembered, represent the leading firms in British engineering, are at present able to recruit only three out of every four graduates for whom they advertise. That there is an urgent need to increase the numbers of graduates is thus obvious. But the figure of 25 per cent. shortage of university graduates can be misleading and may well be an underestimate. The demand for such men is rising all the time with the increase in the general level of industrial activity, and the increased awareness of firms of their need for trained technologists. The gap between supply and demand is thus bound to grow unless the steps now being taken to increase the volume and quality of engineering education become even more vigorous than they already are.

Importance of Quality

10. Most of the firms which co-operated in our inquiry were concerned to impress on us that quality of personnel is every bit as important as numbers. Quality, however, is a very difficult thing to define and, in a period of full employment and with expansion in almost all sectors of the economy, it is inevitable that there should be an apparent shortage of first-rate apprentices and university men with the desired qualities of leadership and initiative. We have, of course, to distinguish such personal characteristics from the quality of the knowledge possessed by the student apprentice or the university graduate. While university training is not a necessary condition for the emergence of the former qualities, we consider that they are more likely to develop in the atmosphere of a university, where the student has an opportunity of rubbing shoulders with people whose interests lie in other fields. It is, however, also contended that engineering is not attracting its fair share of the available talent. This, we feel, is bound to continue so long as engineering enjoys a lower prestige than other professions in many schools of standing, and so long as only a few of the best pupils elect to take up engineering. Finally, we wish to point out that there has been a very great advance in the general level of engineering knowledge, and that firms now expect much more than they formerly did from the engineering graduates they take on. It is up to the industries concerned to make their views more clearly known to the universities if the situation about which they are complaining is to improve.

Preference of firms for first degree graduates as against those with higher degrees

11. Fifty-four engineering firms answered the question as to whether they preferred to recruit graduates (i) directly after their first degree, (ii) after a period of post-graduate instruction, or (iii) after a period of research. Twenty-four of them preferred to recruit men immediately after their first degree, without any qualification; a further sixteen said that they normally preferred (i) but liked a few men with post-graduate or research experience for specialised posts, especially on the research side of the business; three

firms preferred graduates who had done a post-graduate instructional course ; and only one firm chose without qualification men who had done some post-graduate research. In addition to these, four firms answered "It depends on the vacancy" ; five firms had no preference ; and one firm thought it depended on the degree taken. There was thus overwhelming support for recruitment at the first degree stage except for special research posts. Among the nationalised industries, the position was very similar, and post-graduate experience was only considered desirable in exceptional cases for research posts.

12. The commonest reason advanced for the preference for new recruits at the first degree stage was the matter of age. It is argued that a graduate who spends an extra two years at the University on work which is generally held to be of doubtful value, and then two years on National Service, will not be ready to enter industry until he is at least twenty-five years old. This is beyond the age a man should be when he starts getting practical experience of industry, and delays too much the age at which he should be ready to assume effective command. A subsidiary reason advanced was that, once a man stays on at the University for a period of post-graduate study, he tends to stay in academic life (including teaching) and is less likely to seek a career in industry. A number of firms recognised the value of post-graduate instructional courses but suggested that these had greater value if they were postponed until the man had some years' experience in industry. It was suggested that the universities should ensure that the kind of post-graduate work they encouraged was not of a kind better done in industry.

13. We have considered carefully whether these replies call for any modification in existing plans to expand post-graduate work in engineering at the universities, and in doing so have had the benefit of the advice of the University Grants Committee. The Committee has recognised for some time past that there may be a conflict of interests between the development of university research in the applied sciences and the immediate needs of industry. In notifying certain universities of special recurrent grants for the development of higher technological education during the last three years of the present quinquennium (1954-55, 1955-56, and 1956-57), the Committee stated :

"While the Committee fully appreciate the importance of research and post-graduate study as a means of enabling the student who has just obtained a first degree to acquire more specialised qualifications, it has to be remembered that a stage will come with most students when, although they may be far from fully qualified, they will benefit more from some practical experience before undertaking further study than by an immediate post-graduate course. Apart from this, there is a certain conflict between the claims of post-graduate work and the immediate need of industry for technologists. From this point of view the Committee have found the proposals for the expansion of post-graduate work which they have had before them somewhat disturbing in the aggregate. The matter is not one on which it is possible to give any precise directions and the Committee can only ask that the considerations which they have mentioned should be borne in mind and that a broad view of the national interest should be taken in planning post-graduate developments."

14. Post-graduate courses of instruction are, however, an exception to this general view, and are one form of post-graduate work in technology which, in the University Grants Committee's view, requires development. With the growth of scientific knowledge and the development of techniques depending on it, the training of the man who has just taken a first degree in a technological subject falls increasingly short of that required by an effective technologist in industry. The remedy for this is not, in the University Grants Committee's view, to lengthen the course for a first degree, but to provide highly specialised post-graduate courses of instruction, preferably for men who have had some industrial experience after taking their first degree. With the Committee's encouragement, certain universities have provided a number of such courses, but the response of industry has in many cases been disappointing. The University Grants Committee and the Universities recognise that courses for such students may well have to be different both in duration and content from the more normal post-graduate instructional course, and further attempts are being made to meet these special requirements. Further progress will depend on the availability of maintenance grants for students taking these courses. Hitherto grants have been more readily available for research than for post-graduate instruction, and as a result the balance between these two forms of post-graduate work may not have conformed as closely as it should to the public interest.

15. The special grants made to the Universities for the development of higher technology became effective only in the academic year 1954-55. The University Grants Committee does not therefore consider it opportune now to make further suggestions about the development of technology. By September, 1956, the universities will have decided their development plans for the quinquennium 1957-62, and any new proposals which the University Grants Committee might make would have to be put forward in the light of these plans and of the developments that have been accomplished as a result of the special financial stimulus provided in the last three years of the present quinquennium.

Apprenticeship Schemes

16. Most of the larger firms have a wide variety of apprenticeship schemes, to which they attach great value. Apart from graduate apprentices, who are given two years' practical training after taking a degree at the University, the two main types of apprentices are craft or trade apprentices on the one hand and student apprentices on the other. These are called by a variety of different names, according to the firm and the locality, but the broad distinction between the two classes of apprenticeship is valid in most cases. Craft or trade apprenticeship is designed to produce skilled workers and technicians. The age of entry is normally sixteen years and the length of training about five years. In some cases, but not all, training includes some theoretical instruction either at the works or the local technical college. The term "student apprenticeship", as used in this report, covers boys recruited at ages varying from sixteen to eighteen years. The greater number of these boys have passed G.C.E. at the ordinary level, and a fair proportion have passed at the advanced level in two or more science subjects. They are given a combination of theoretical and practical training for a period of five or six years, and the best of them eventually become professional technologists.

Student apprentices generally have one day or more a week off from the works to attend a local technical college, and are encouraged to acquire professional qualifications, starting with the ordinary National Certificate, and proceeding thence to Higher National Certificates and/or external degrees and professional membership of engineering institutions. Some of the brighter boys who start as trade or craft apprentices are promoted to student apprentices.

17. A number of firms have commented on the fact that boys with qualities of leadership and initiative tend to come from middle-class homes with a long tradition of responsibility, and that many such boys have not gone to the University owing to the combined effect on their parents' incomes of taxation and the financial contribution required from them. Student apprentice schemes offer the best of these boys a chance of education at a firm's expense. As one firm put it "Student Apprenticeship in the modern context implies that industry pays for the development of the young man who rapidly becomes self-supporting instead of continuing from Public School to University as a charge on his father".

Sandwich Courses

18. These are a variant of the apprenticeship schemes, designed in general to give the student a chance of a more fundamental theoretical education than is possible under a system of day-release. Such courses are at present being expanded considerably, as a rule by co-operative arrangements between industry and the technical colleges. The most usual arrangement is for the boy to spend six months of the year full-time at a technical college; the balance of his time is spent at the works, with the exception of two weeks' holiday.

19. One type of sandwich course, which has found increasing favour with a number of firms in recent years, is the "one: three: one" system, under which a boy spends one year's apprenticeship at a firm followed by three years at a University and a final year's apprenticeship after graduation. The boy would need two years' training in industry in any case, and it is felt that he is likely to get more benefit from his time at the University if he has already had one year in industry. In some cases, firms assist the boy financially during his period at the University, especially in the case of boys whose parents are prevented by their level of income from getting any financial assistance from the State. One firm suggested that any further expansion of the technological departments at the universities might well make a period of practical training an essential qualification for entry to the university. The University Grants Committee do not, however, consider that the advantages of this system are so generally accepted or so universally applicable in all branches of engineering as to justify their suggesting to the universities that such a practice should become compulsory.

Progress of ex-Student Apprentices Compared with that of Graduates Entering Industry from the Universities

20. It is generally agreed that student apprentices who stop at the ordinary National Certificate are unlikely to progress very far, except perhaps on the sales side of the business. Those who obtain Higher National Certificates, on

the other hand, are considered eminently suitable for posts at all levels on the production and technical sides, and a number of firms (especially in the aircraft and motor car industry) prefer such apprentices, owing to their greater practical experience, to graduates recruited direct from the University. Some firms argue that it is extremely difficult for graduates entering industry for the first time at the age of twenty-three or twenty-four ever to catch up in industrial experience with their fellows who have been "industry trained". An exception is generally made for special posts in research or development, and for men destined eventually for senior posts in technical departments. It was however suggested by one firm that, whereas student apprentices with Higher National Certificate have done good service in the past, University graduates will dominate the future. Two firms consider that ex-apprentices with Higher National Certificates are equal in merit to graduates with a pass degree, while apprentices with external degrees compare favourably with honours graduates. The extensive unsatisfied demand for engineering graduates does, however, suggest that industry recognises the particular value of the university graduate.

21. The importance of personal qualities—character, initiative and powers of leadership—were stressed in a great many of the replies which we received. Those personal characteristics which might be said to depend on the man's training were, however, given very varying weight. Some firms held that graduates do not easily adjust themselves to the "rough and tumble of industrial life" and prefer "white collar duties". Against this it was suggested that the best graduates benefit from training in analytical thinking and are more likely to be willing to accept responsibility. As between apprentices who take external degrees and the conventional graduates, it was argued by some firms that the former benefit from the added practical experience, while other firms considered that the apprentice loses through excessive concentration in a narrow field in the formative years. In general, it seems to be agreed that the differences between the two types of men tend to disappear by about the age of thirty.

22. Several firms stated that their student apprentices are encouraged to go as far as possible in the educational field, and that the best are normally encouraged to take degrees, either by external studies or by sandwich courses of one kind or other. On the other hand, some complained that apprentices who gain external degrees tend to leave for firms giving better possibilities of promotion; or that ex-apprentices with degrees tend not to return to the company after completing their National Service.

23. The conclusion, in so far as one can be drawn from the replies we received, appears to be that industry needs both good student apprentices and good graduates, and that the two are to a large extent complementary, as they are often employed on different work. For the man with a capacity and taste for intellectual work, the universities give the best chance to develop; but for the man with more practical tastes it is felt that the student apprentice schemes have much to offer by way of extra industrial experience at a relatively early age. There is a fairly wide range of talent which could probably benefit equally (though in different ways) from either method of training.

Effect of Expansion of Universities on Quality of Student Apprentices

24. There is no clear agreement as to the effect of University expansion on the intellectual level of boys available as student apprentices. Several firms complained that the quality of boys applying for jobs as student apprentices had already deteriorated considerably since the 1944 Education Act, which led to the "creaming off" to the Universities of too many of the brighter boys. Others stated that so far they had managed to obtain good quality apprentices, but they expressed concern at the effect of further expansion of the universities. As one firm put it:—"Because we enjoy some reputation as employers and as a training organisation, we have just been able to maintain our establishment of trainees without lowering our standards, but it appears that from now onwards we shall have not only to battle for our university engineers in the talent-scouting circus, which each year circulates the Universities, but that we shall henceforth have to labour in the dust of the arena to secure the number and standard of boys that we require for student apprenticeship. All of this is going to happen at a time when the demands of this Company and its Associates overseas for the graduate and the student apprentice engineer are increasing." A number of firms however felt that the need for more graduates outweighed other considerations.

25. It is, of course, obvious that if the size of the potential population from which apprentices and university graduates in engineering are drawn were fixed, any increase in the latter would tend to diminish the numbers and lower the quality of the former. We cannot, however, see why the potential size of this population should be regarded as fixed at its present level. The Ministry of Education tell us that the number of boys and girls who stay on at school until seventeen or eighteen has been increasing steadily over the last few years. Even so their recent report on Early Leaving from the Schools* showed very clearly that there is a substantial reservoir of untapped talent, and that for every two boys who stay on at school after the age of sixteen, another boy of at least equal talent leaves. If more of the latter could be persuaded to stay on for sixth form work, and some of them eventually became engineers, they would be available to feed the universities and also the many apprentice schemes now in operation. The Ministry of Education consider that this can be achieved, and are accordingly pressing on their efforts, in collaboration with industry, to extend the facilities in technical colleges for student apprentices in engineering. In Scotland, too, there is a considerable reservoir of talent in the secondary schools and the facilities for technical education are being expanded so as to absorb any increased supply of students. Moreover, there will be a very substantial increase over the next ten years in the number of boys reaching the age of eighteen, owing to the bulge in the birth rate immediately after the war. The Committee on Scientific Manpower does not therefore believe that any likely increase in the numbers of engineering students in universities need make a material reduction in the numbers, or in the quality, of the student apprentice population for some time to come. It is, however, necessary for the schools to maintain a balanced attitude towards the different ways of training to become an engineer.

* "Early Leaving": A report of the Central Advisory Council for Education (England).

Attitude of different sections of Engineering

26. Table II divides the figures of annual recruitment by engineering firms into main industrial groupings. Eight big firms engaged in a wide variety of heavy and light mechanical and electrical engineering dominate the picture so far as graduate intake is concerned, and were responsible for 580 out of the total average annual intake of 974 science and technology graduates in 1951-53 (i.e. nearly 25 per cent. of the total university output of graduate engineers). These firms differed from the others in our sample in that they recruited more graduates than student apprentices. This does not necessarily mean, however, that they continue to employ a higher proportion of graduates to ex-apprentices than other firms, as they tend to act as a training ground for graduates who later find jobs in other firms with fewer facilities for post-graduate training.

27. The second biggest group in these statistics is the *aircraft industry*, which accounted for an average intake of about 200 science and technology graduates in 1951-53. Recruitment by this group of firms rose sharply during the period (from 154 in 1951 to 256 in 1953). The number of student apprentices averaged 324 per annum and rose roughly in proportion to the graduate intake.

28. Eleven firms in the *general engineering group* together recruited only 55 science and technology graduates per annum, as compared with 146 student apprentices and 764 trade apprentices. Most of these firms complained of their inability to find suitable graduates. In the *motor industry*, on the other hand, the graduate intake has been low, but this is not attributed so much to the lack of candidates as to the fact that the industry generally prefers to train its own men. The three firms of *shipbuilders* which we consulted recruited no graduates of any kind in 1951-53, and only eight student apprentices per annum. One of the three pointed out that they carried out no original design or research work, and suggested that this was "common practice in the Marine Engineering Industry, which relies on the various research bodies . . . to keep the industry abreast of current developments."

Conclusion

29. Our inquiry has clearly established that a fear does exist in some quarters that the expansion of higher technological education and research by institutions of university status is detrimental to the interests of certain sections of the engineering industry. One of the main worries is that such men as go to the Universities to take up engineering are likely to stay there too long, and to study and to do research on topics of little value to industry. Another is that the increase in the size of the University population is "creaming off" talent which would otherwise have entered industry directly as apprentices.

30. Widespread though these fears may be, the Committee on Scientific Manpower is not persuaded by the arguments from which they spring. It is first of all obvious that these views relate to only one, even if important, section of British industry as a whole, and even so that they do not represent the opinions of all the engineering firms concerned. Second, it is not only plain that engineering firms require good graduates as well as good apprentices, but that however much the engineering departments of the universities may have expanded already, they are not, even on the basis of present demand,

turning out enough men to provide our engineering firms with more than about three-quarters of the graduates they want. Thirdly, we are confident that, even if the universities were to expand further, and the number of students who wished to take engineering increased correspondingly, there would still be enough available talent in the population of boys and girls who do not go to a university to provide industry, over the next decade, with all the good apprentices which it might wish to recruit directly for its apprenticeship schemes.

31. We are very impressed by the fact that even a section of British industry, which has been concerned lest expansion of technological departments at the universities would deprive it of good apprentices, cannot recruit more than three in four of the university graduates it wants. Whatever happens to apprenticeship schemes, the demand by industry for scientists and technologists trained to graduate level is bound to increase at an ever-expanding rate in response to the rapid growth that is taking place in scientific knowledge. Some of the firms we approached appreciate this point fully; at the other end of the scale are those who neither yet want the university trained scientist/engineer, nor indeed have much call for student apprentices. This will have to change if these firms, and British industry, are to maintain their present competitive positions. The future of our country is vitally dependent on advances in technological knowledge, and these must stem from research work at the universities as well as in industry and government laboratories. In any event, the scale of post-graduate research work in engineering which is contemplated for the expanded university departments as a whole is no greater than is necessary to ensure that these departments will thrive as scientific institutions.

32. We fully appreciate that engineers need a considerable amount of practical training in industry in addition to theoretical studies at the university. Student apprentices are given a combination of practical and theoretical training which can produce very good results, especially where the system is the "Sandwich Scheme", with for example six months in each year full-time at a technical college. At the same time it is clear that, to keep up to date with new scientific developments and with the increased complexity of industrial processes, there is an urgent need for the multiplication of post-graduate instructional courses, as opposed to engineering research, at the universities. Here, as we have already emphasised, is where industry must get together with the universities to make its needs better known.

33. Quality, of intellect and personality, is no less important than quantity, both in the case of university graduates and student apprentices. Some firms have alleged that the graduates of to-day are inferior to those of pre-war, and are concerned lest the continued expansion of the universities should cause a further fall in the calibre of the under-graduates admitted, as well as increase the difficulty of integrating students into the life of the university as a whole. We agree that this may be a problem, but would emphasise that there is no real evidence that the intellectual ability of graduates has in fact declined since the war. On the contrary, and to the extent that this constitutes a test, the proportion of first-class and upper division second-class degrees remains very high in the science and engineering students who now emerge from the universities. What needs to be remembered, as we have emphasised earlier, is that this is a period of full employment, and with all sectors of our economy expanding, the impression is

bound to spread that there is a lack of first-rate ability among the new recruits to industry. Moreover, the standard of engineering and scientific knowledge that is required is rising all the time ; a fact which is also likely to create misleading impressions about the ability of the new recruits to industry.

34. This is not to deny that a career in industry, and in the engineering industry in particular, still appears less attractive than it should to enough boys of intellectual ability and outstanding character in some of our schools. We have stated before, and we repeat again, that those who influence the choice of careers, particularly parents and masters, have a special responsibility to see that attention is directed to the fact that a career in engineering can be as rewarding, both intellectually and materially, as any other career. The universities also have a responsibility to see that under-graduate courses in engineering do not become too narrow and specialised, and in turn cramping to men of strong initiative, and of wide and original interest.

35. The future of our engineering industry, on which the whole of industry must be increasingly based, depends on such men, and in far greater numbers than are coming forward today. This fact we accept without question ; it is only in the diagnosis of the cause of the shortage and of its remedy that we differ from the number of firms who have provided us with information and who attributed their difficulties in obtaining apprentices to the post-war expansion of university education in science and engineering. In our view, the shortage of good graduate engineers is of first importance, and we believe that measures which are being taken to relieve this shortage need not, and will not, reduce the number of good recruits for apprenticeship schemes. But in saying this we are acutely aware that the demand for highly-trained technologists is going to grow, and at an ever-increasing rate as fields like electronics and nuclear energy are exploited, and as more and more established fields of industry apply modern techniques. Only the strongest measures will prevent the present gap between supply and demand becoming greater than it already is.

Acknowledgements

36. In conclusion the Committee wish to pay tribute to the large number of firms who have co-operated so generously in the work. This has involved a considerable amount of research and thought on the part of those concerned.

(Signed) On behalf of the Committee,

S. ZUCKERMAN,

Chairman.

September, 1955.

TABLE II. RECRUITMENT OF SCIENTISTS AND ENGINEERS BY DIFFERENT SECTIONS OF THE ENGINEERING MANUFACTURING INDUSTRY

(Annual Average 1951-53)

	GRADUATES				Holders of National Diplomas	Student Apprentices	Trade Apprentices	Other Personnel	TOTAL
	Science and Technology		Other Subjects						
	Higher Degrees	First Degrees	First Degrees	First Degrees					
—	21	559	27	8	148	492	1,568	218	3,033
8 firms covering a wide variety of heavy and light mechanical and electrical engineering products	2	70	8	5	57	87	159	16	399
6 firms engaged in light engineering, instrument making and electronics	3	52	5	4	24	146	764	92	1,086
11 firms engaged in a variety of general engineering and metal fabricating work	2	12	4	1	1	34	94	—	147
2 firms in the metallurgical industry... ..	—	12	1	1	4	15	190	1	223
6 diesel engine makers	9	197	12	12	43	324	933	20	1,538
7 aircraft and aircraft engine makers	—	—	—	—	—	8	194	4	206
3 shipbuilders	2	11	13	13	9	58	215	71	379
5 motor car makers	—	22	—	—	7	9	39	68	145
2 civil engineering contractors	39	935	70	—	293	1,173	4,156	490	7,156
TOTAL	39	935	70	—	293	1,173	4,156	490	7,156

TABLE III. DEGREES, DIPLOMAS AND HIGHER NATIONAL CERTIFICATES IN TECHNOLOGY IN GREAT BRITAIN

—					1938-9	1950-1	1951-2	1952-3	1953-4
INTERNAL AWARDS									
<i>University Degrees:</i>									
First Degrees: Honours	...	...	...	...	482	1,266	1,414	1,263	1,187
Pass	...	...	...	...	463	1,062	987	909	867
TOTAL					945	2,328	2,401	2,172	2,054
Higher Degrees	...	...	...	...	144	313	310	374	360
<i>Diplomas*</i>									
University Diplomas†	...	...	...	...	625	1,103	1,020	1,058	1,164
Higher National Diplomas	...	...	...	...	62	412	304	366	296
EXTERNAL DEGREES									
First Degrees	...	...	...	...	103	532	364	406	282
Higher Degrees	...	...	...	...	10	6	7	15	2
HIGHER NATIONAL CERTIFICATES									
Total...	...	...	...	...	1,332	5,749	6,340	6,555	6,823
which includes:									
Mechanical Engineering	...	...	...	...	681	2,965	2,920	3,004	3,025
Electrical Engineering	...	...	...	...	435	1,546	1,906	1,955	2,048

* In addition to the figures shown, there are at present over 400 college diplomas or associateships per annum. Figures for past years are not available.

† Including Royal Technical College, Glasgow and Manchester College of Technology: a large proportion of these diplomas are awarded to graduates in technology.

APPENDIX I

EXTRACTS FROM LETTERS FROM FIRMS IN THE ENGINEERING INDUSTRY

I. Firms covering a wide variety of heavy and light electrical and mechanical engineering products

A. "Our experience at the present time is that there are insufficient science and engineering graduates of high quality emerging from the Universities. This refers not only to academic prowess, but also to personality, general ability and power of leadership. It is unlikely that men of this calibre are being missed by the University selection machinery and it is probable that the numbers can only be increased by diverting the very able men from other faculties, such as Arts and Classics . . . Amongst the electrical engineers there are far more offering degrees in light current than heavy current engineering and it is becoming increasingly difficult to find men even for training in the heavy current field".

B. "On the question of the value of the university graduate to industry, we consider that a man who has taken a university degree shows better administrative qualities at an early age than a man who develops his career the hard way through student apprenticeship and higher national certificate course. This is because the latter has to concentrate very narrowly on his work to make the grade and his education and training tend to be highly specialised. A student apprentice with more than average ability may take longer to develop executive ability than a university graduate. Comparing men of equal ability, the difference is noticeable at the ages of 23-25 but, with equal industrial opportunities, differences may disappear in the early 30's. . . . We consider that an expansion of university facilities for technological students must cause some loss of direct intake to industry unless there is a very much greater awareness of the need for a campaign in the schools to encourage a higher proportion of pupils to come into engineering . . . We believe there is great value in young men joining industry straight from school as student apprentices and having an opportunity of going to university after one or two years' apprenticeship. This gives the employer the opportunity of assessing the worth of these men and the apprentice benefits by an early association with industry . . . We believe that universities must be persuaded that practical training is an essential part of engineering training . . . In conjunction with the possible expansion of post-graduate courses, we strongly advocate that students spend twelve months in industry between the attainment of the first degree and starting the post-graduate course; our experience has been that men who go straight through to Ph.D. without much previous contact with industry tend to branch off into other fields such as teaching or research . . . The comment is, I think, justified that many technical students now at universities are barely worthy of a place and far too many students have only average abilities. If numbers are increased at the expense of quality, there could be no gain to industry by the expansion of such facilities and, if I may express a personal view, there seems to me a danger that a part of the real value of the university may be lost. Apart from any academic attainment resulting from a university course, it has always been recognised that a university education gives special opportunities for mental development in its broadest sense and the opportunity of acquiring a balanced outlook on life through participation in extra mural activities. The ultimate value of a university education to a man must surely be at least as much in the participation in university life as in the specialised course he may pursue."

C. "Having dealt with the questionnaire, perhaps I might make a few general comments. Regarding the number of men required by the electrical industry,

I believe this is directly related to the rate of growth of the Industry, which as you are probably aware is at the rate of 8 per cent. per annum. To cope with this business, our experience shows that an increase of staff at the rate of 4 per cent. to 6 per cent. per annum is required . . . Generally speaking, we prefer a good engineering graduate with an honours degree from a recognised university or technical college. We regard two years' practical training in industry as essential and one of our greatest criticisms of post-graduate work for engineering students at the universities immediately following a first degree, is that it often unfits the man for practical training, which we consider so essential.

If we cannot get a good honours graduate from the University we prefer to take, as our second line, a good student apprentice trained on an industry based sandwich course rather than the less successful university graduate."

D. "It is clear that there is need for a considerable increase in the scientific and technological departments in the English and Scottish Universities to cope with the present demand for graduates. Many firms who, in the past, have neglected to recruit this type of man are now seeing the red light and are attempting to put matters right at a time when even the ordinary demands of more far seeing companies cannot be met. I am aware of several companies in this area alone who have never recruited graduates and are now faced with the inevitable results brought about by retirement, expansion, illness and death. These companies, for too long, have been living on their fat, or their complacency, and relying too often on more forward looking companies to do the training. There is also a need for more guidance to men entering Universities as there would appear to be too many entering the arts and the "woolly" side of Universities and not enough recruits are coming to the "bread and butter" sides. Even those who do go in for engineering are inclined to evade heavy engineering and are attracted to electronics, aero engines, guided missiles, etc. . . . Many young persons entering industry at the ordinary and advanced levels of the General Certificate of Education are undoubtedly capable of taking full advantage of a University education. I am enclosing a booklet outlining our Apprentice Advancement Scheme, in which there is a description of our "Sandwich" Scheme of training open to the lad with the requisite standard of education. We have between fifty and sixty apprentices taking this "Sandwich" Scheme of training which allows them to take a full time course of five months at the College and seven months at the Works for two years, but, in the third year, it is seven months at the College and five months at the Works. A large proportion of these young men go on to take their Higher National Certificate and many of them apply for, and are granted, a Scholarship to enable them to go to a University and take their degree. If they are successful in this, we give them a further grant whilst they are at the University to enable them to take full advantage of the course. We have at the present time about ten students at King's College taking their degree who will come back to us, and this scheme could be expanded."

E. "I would express concern at the effect that the expansion of undergraduate facilities in our universities might have on the number and quality of boys entering industry as student apprentices. The danger is to assume that these boys will be better educated and trained as professional engineers or technologists by their following university studies with, therefore, a consequent shortening of their industrial training. That in general they may require better educational opportunities than those available under normal part-time release arrangements I am prepared to concede; indeed, my Company has already taken appropriate steps to this end. We also feel that greater attention in industry might be given to the selection of student apprentices as persons to be deliberately

trained as professional engineers or technologists. In short, industry requires in its professional ranks not only boys who have been educated at universities but also those who have spent their formative years in industry. The one group is the complement of the other and both require to have had a good schooling up to about 18 years of age. I am also concerned with the possible development of post-graduate facilities in universities that in general may have no other substantial result than to delay the admission of graduates into industry. Development of this kind on a wide scale may mean that, with national service, men will not enter industry for the first time until after they have reached 25 years of age. In any event it is important to try and ensure that post-graduate university schools are engaged on technological work of importance which is not better done in industry itself."

F. "In view of the present shortage of technologists, we support the suggestion that opportunities for university education should be increased, providing that selection of the additional candidates is made without a lowering of entrance standards.

On the other hand, we attach considerable importance to the 'student apprentice' category of employee and encourage these young people in their pursuit of further education and training."

II. Firms engaged in Light Engineering, Instrument Making and Electronics

A. "I am sure that the opportunities for University education, in particular the scientific and technological departments, should be expanded at both undergraduate and post-graduate levels. There are by no means enough scientific personnel now available for industry, and an expansion at both levels, because a proper balance will have to be maintained, is desirable. More attention may, however, have to be given to financial assistance for those who can profitably take advantage of the increased facilities. There are probably many boys who, although they would be suitable for this education, would find it very difficult to meet the cost.

On the present serious shortage of good scientific personnel, the effect of such an expansion would be beneficial to industry. Not only would industry get a more adequate supply, but it would have a rather better choice, with a resulting improvement in the quality of the work done. On our research side, we want persons with particularly good degrees (usually first class honours), and are often unable to get the type of person we want from the graduates presenting themselves for interview. We are also forced, on occasion, to use junior engineers when we would prefer more senior persons.

Although we attach a great deal of value to the training of student apprentices—on our research side in particular—we really prefer a University trained man. The company has a student apprentice scheme in which boys are given a five years' training, either for a degree or for the Higher National Certificate, and, in addition, we have a subsidiary where full time training in electronics is given up to general degree standard. A proportion of the students of this school of ours is taken into the company.

It is debatable whether the expansion of University facilities for technological students will, in the long run, have any adverse effect on the quantity of boys entering industry as student apprentices. Initially, the intake of trainees would probably be affected but in the long run, provided a proper balance is kept of the numbers at the different levels of education and training, it seems to me more likely that there would be no adverse effect on our recruitment of student trainees. Similarly, the expansion of the numbers of post-graduate students ought not, in the long run, adversely to affect the number of first degree graduates entering industry, although there might, of course, be an initial adverse effect."

B. "We believe that any large expansion of University facilities for technological students may well have an adverse effect on the quality of the boys entering industry as student apprentices.

As far as progress is concerned between former student apprentices and graduates entering industry from University, our conclusion is that up to between twenty-eight and thirty years, progress is about the same, but from then on where senior positions are to be considered, the more widely experienced and trained University graduate makes the better progress."

C. "It seems to me that a problem is raised by the potential graduate having to leave Grammar School at sixteen years. Ways of assisting the able boy to stay at school until eighteen should be considered. I make this point because we can make a surer judgment of the potential in an eighteen-year-old than in a sixteen-year-old whose character and ambitions are often still very fluid. Also the experience of responsibility gained by two years as a senior in a good school is very valuable. A boy can lose valuable time by starting on a course at Technical College which is either too stiff or not stretching him to the full. Public Schools say very definitely that the advantage of their system is only reaped by boys staying on after sixteen.

We certainly need a better choice of science graduates and while we welcome any steps that will increase their numbers I feel that the 'Sandwich' Scheme which breeds 'home-grown' engineers will ultimately prove the best solution to the problem."

D. "We generally prefer to take on people who have already been brought to earth by a few years' experience in industry though on the Central Research Side, which deals in fundamental research, we do recruit a few straight from the University.

On the whole it is rarely that we go out for a Ph.D., although an odd one here and there does no harm but, given that we can get our fair share of the brilliant and can succeed in controlling their flights of fancy, we tend to have rather lower standards and prefer to take on people who, in our fallible judgment, may one day prove to be good men and administrators."

III. Firms engaged in a wide variety of general engineering and metal fabricating work

A. "We have the greatest difficulty in recruiting graduates even with third class degrees and the position is not much better in regard to people with the General Certificate of Education Advanced qualification.

With the recent extension of University grant facilities it is reasonable to say that most young people leaving Grammar Schools with a good G.C.E. Advanced qualification can secure State, County Major, or other scholarship awards which will carry them through a three year University course. In general, only those with somewhat dubious performances in the G.C.E. examinations are presenting themselves to us for employment. We urge these people to push on with advanced studies and this they do, usually only with moderate success. Those who have made the grade and have secured external degrees at London University, have left the Company's service within a few months.

We feel that improvement in the general situation must therefore arise from greater availability of graduates trained in Science and Engineering subjects."

B. "The indications are that at the present time the disparity between available manpower and posts in industry is even greater than was the case two or three years ago, and extreme difficulty has been experienced in filling posts, particularly those of a highly specialised nature, such as ceramics and aerodynamics."

C. "I may add that it has not been our practice to specifically recruit graduates or post-graduates in the terms of your enquiry, preference being to develop our people 'the hard way' with practical training in our shops running parallel with academic studies.

There appears to be no doubt that Universities must make provision for expansion in view of the ever-increasing progressive trends in the scientific and engineering fields, but whether this may have an adverse effect in regard to the quality of boys entering industry as student apprentices, etc., etc., we think depends upon the extent of the expansion."

D. "The position with us as regards chemists and chemical engineers is tight but not impossible, perhaps because we have always had a fair nucleus. The recruiting of graduate mechanical engineers to the engineering side (initially to the Drawing Office), however, has been operating for only four years past, and we find the position there tighter. Incidentally, we have one small but still somewhat troublesome feature, that it is more difficult to retain graduates (especially southerners) in this part of the world than in the South. . . . Each year we choose three or four of these apprentices with the best overall reports (which is not only to say who rate highest academically) and we send them to Constantine Technical College at Middlesbrough to study for the Higher National Diploma in Engineering or in Chemistry, during three years of full-time attendance. All of their vacations except the usual holiday fortnight are employed in the ordinary way in our organisation. For three years past we have been selecting a sufficiently qualified young man (Higher National Diploma or graduate) for full-time attendance at a Fuel Technology Diploma Course in Newcastle at Kings College at Durham University. All of these young men receive full pay, as well as their college or university fees and (if necessary) a living allowance. Besides this, we award one scholarship per year (£95) at Durham University and one (£150) at Leeds University. The recipients invariably get a supplementary grant from the County Educational Authorities."

E. "The able sixth former in the Grammar and Public Schools is most fortunate that he has a wide choice of first class student apprenticeship, leading to membership of the professional Institutions, or of taking a County Major to University and a degree. A nice question worthy of some study is whether the means test on University grants will result in parents in the middle income brackets channelling their sons into student apprenticeship. Student apprenticeship in the modern context implies that industry pays for the development of the young man who rapidly becomes self-supporting instead of continuing from Public School to University as a charge on his father.

Our graduate intake has included a small number of Arts men, mainly in the field of Representation, but we require in the Arts graduate a considerable degree of interest in things mechanical. It is fair statement that had the number of Engineering and Science graduates applying to us been higher, we should not have thought of training the Arts man for representation as there is some advantage in having Engineers as representatives. . . . Our direct entry standards for graduates and for student apprentices are undoubtedly high. Craft apprentices are considered for promotion to student grade only after they have obtained their Ordinary National Certificate. Until about 1950, applicants for student apprenticeship satisfying our requirements at the G.C.E. Ordinary Level for five years training and at the G.C.E. 'A' Level for four years training, came forward in quality and numbers and we were able to be highly selective. The implications of the Education Act, 1944, gradually brought themselves to our notice and it appears that the numbers of Grammar School and Public School boys applying to us have tended to decline in quantity and in their qualities. This, to the extent that we have just taken careful stock

of the situation and started an intensive publicity campaign over the whole of the country whereas until now we have been able to satisfy our needs from our own area and from ordinary word of mouth publicity. . . . In the face of what is our own experience, we are surprised to understand that a substantial number of places in the Engineering Faculties of the Universities have not been taken up. It may be that the means test applied to University grants has the effect of making it financially impossible for parents in the middle income group to allow their sons to take up University places even though they are academically qualified to do so. If that thing is happening we are a little puzzled to know why there are not more applicants for student apprenticeship. We know that it costs this Company about £850 to train a craft apprentice ; the cost to us of a student apprenticeship of four years duration is certainly not less than the cost to all concerned of sending a boy to University for three years, and finally it probably costs us not less than £2,000 to provide a post-Graduate Apprenticeship of two years duration."

F. "Our view, for what it is worth, is that the expansion of University facilities for technical studies, particularly if such studies can be made concurrently with some practical experience in industry, has much to commend it.

With regard to your questionnaire, we feel that you would obtain more valuable data by getting in touch with much larger organisations than our own. They naturally have a large Personnel Department and comprehensive training schemes of the type in which you are mainly interested."

G. "From experience, it is thought that there would be no adverse effect by expanding the University facilities for technological students, as quite recently we have engaged a number of Student Engineers from Grammar Schools with General Certificate of Education, Ordinary Level, who would have been able to gain admission to a University had they remained at school and taken Advanced Level. For quite a number of reasons (financial in most cases), they prefer to enter industry and gain their technical qualifications on a part-time day attendance basis. Another reason for this is National Service. A young man, upon reaching eighteen years, approximately, and still at school, is usually due for call-up. He would then proceed to a University at twenty years of age. Provided he does not fail in his studies, he will be available to industry at twenty-three years, with little or no experience, and then, of course, the financial aspect has to be considered."

H. "I do not think that the points which you make can be dissociated from the problem of our ageing population and the fact that in the next ten years the number of persons going through educational establishments of all types will be reduced and, from present statistics, would seem likely to remain at a lower level and to be even further reduced in twenty years. I therefore hesitate to suggest that an expansion of university facilities would adversely affect the number of graduates entering industry alone ; but I think this would be a contributory factor to the overall problem which we shall probably have to face through a shortage of this type of manager."

I. "Expansion of post-graduate instructional courses might increase the number of graduates who stay on at the University after taking a first degree, especially where the graduates are following the old procedure of completing their degree courses before taking up practical training in industry. But where the 1:3:1 pattern is being followed, namely, one year in industry, three years at the University, and one final year in industry (an arrangement which is becoming increasingly popular, and which we ourselves strongly recommend), it is unlikely that the graduate would ask his sponsoring firm to increase the middle period to four years so that he could stay on at the University for a post-graduate

instructional course. He would more probably obtain such a course at a local Technical College."

J. "As regards trade apprentices, we naturally prefer boys from Technical Secondary Schools, because they have much less difficulty in connection with their studies in technical colleges, under part-time day release and in evening classes, but a few come from grammar schools."

IV. Firms in the Metallurgical Industry

A. "We need scientists and engineers and other technologists as urgently as anybody in the industry but we also want, as most other firms must do, men with real qualities of leadership. Without sound human leadership scientific prowess is obviously not going to get us very far. Yet the thing which impresses us about the undergraduates and graduates whom we interview each year is the very great proportion who lack any real leadership qualities.

This is no doubt due to many causes. One is particularly significant and has been spotlighted in a number of recent reports and studies. Leadership qualities owe a great deal to family background and are produced most commonly (not exclusively) where there is a home atmosphere of responsibility or command. Unfortunately the present systems of taxation and financial aid for education appear to be reducing the number of boys of this background who take university degrees or good technical college courses. Nor of course do such boys normally come into the industry at the present levels of recruitment from secondary and local grammar schools. We are now proposing to go out after such boys by recruiting them from grammar and public schools into a special training scheme which will include the chance of a university education.

Our feeling here about your specific proposition is that an increase in technological education facilities would inevitably mean a further raid on the class of boys who are educationally just below the minimum standard which at present qualifies for grant-aided university entrance. This would mean to us a loss of the lowest grade of technician trainee, but for the reasons I have given would mean no significant loss of managerial potential.

About the effects of more postgraduate instructional study I have much less definite views. . . . Broadly speaking however my reaction would again be that better academic training for the existing undergraduate population will only be of optimum value if a higher proportion of real leaders can somehow emerge."

B. "Our present policy is to recruit both at the graduate level and through young men who join us between the age of 16-18 years. We feel that there is ample scope for both, and our experience so far has not indicated any great difference between the two at an age of round about 25 years. Much, of course, depends on the personality of the individual young man.

We certainly favour the expansion of facilities for technological students and more particularly in the University where the standard of education at the present time is likely to be higher than in the Technical Colleges.

If more young men went to the University, it would have an adverse effect on our ability to recruit good young men as student apprentices or their equivalent. However, although this would have an effect on a short term policy in the long run it would be cancelled out and industry would benefit by getting a better trained man. This would be more particularly true if more attention were paid to technological training."

V. A Firm making Diesel Engines

"We are starting a 'sandwich' scheme with Nottingham University, under which we will accept students for one year before they go to the University and again for a final year after they have completed their three years at the University."

VI. Firms making Aircraft and Aircraft Engines

A. "However, the needs of industry may possibly best be met by a large expansion of the technical colleges and their courses leading to the Higher National Certificate, equivalent diploma, or other award. The standard should presumably be something below that of the university bachelor's degree; we gather that the standard of the Higher National Certificate varies a certain amount according to the particular college.

The course would be roughly the equivalent of the American first degree; the numbers who obtain this first degree are very large, over 400,000 in 1950, and of these over 150,000 are available to industry.

The technical colleges would certainly seem to be the best places for these courses and to gain full benefit from them they should either be full time or on the 'sandwich' basis (six months in the factory and six months at the college), though there would presumably be large numbers on a day release basis with evening classes. Our local Technical College has, in fact, started a 'sandwich' course, leading to a college diploma which will be of standard equivalent to the best Higher National Certificate. We here prefer the course to be 'works based' rather than 'college based' and have several of our young men taking it."

B. "Another important effect of expanding the number of University students would be to increase the number of graduates entering industry without industrial experience while decreasing the number of intelligent Works trained apprentices. In a generation or so, unless postgraduate training schemes are enlarged or University apprenticeship (integrating a full Honours degree course with industrial experience) established far more widely to become the standard method of tackling an Engineering degree, industry is destined to be staffed at all levels by too great a proportion of technologists without basic experience. This particular criticism is especially important in the sphere of Production Engineering. There is a danger that concern about the shortage of technologists may cause us to overlook the even greater shortage of technicians. We are mindful of the large and important field of work which lies between the craftsman and the technologist and consider it to be against everybody's interest to take first class technicians from their proper sphere only to turn them into second rate technologists."

C. "It would appear to be acknowledged in many places that the quality of men entering University to take Mechanical Engineering degrees is far from good enough, and, in consequence, the quality of the University output is not high. It would also seem that the position in this respect is not improving and that, in addition, there are likely to be numbers of vacancies in the Engineering Departments at the Universities this next year.

An increase in the opportunities for University education would not benefit industry unless the quality is improved; this can only be done by the industry (possibly in co-operation with the Universities), selling itself as a rewarding and interesting profession in the schools, and by this means persuading many of the young men who at present proceed to Arts degrees, with no specific objective in view, to enter the engineering profession which at the present time offers ample scope and prospects.

We are not yet persuaded of the value to industry of post-graduate work at Universities; in too many cases the work undertaken for post-graduate research is entirely valueless and becomes a pure academic exercise. The work subject is often chosen because a particular piece of apparatus or machinery happens to exist at the University and in many cases the investigation remains uncompleted at the end of the post-graduate period and is continued by another graduate the following year."

D. "Now on the question of the expansion of University openings, we consider that only if pre-University education in our Public, Grammar and Technical Schools is both expanded and intensified can we see any lasting good arising from the proposal, for we are told that few Universities are recruiting annually their full quota of students. Therefore, those who fail to gain University entry usually do so, not on financial grounds (in general the Local Education Authority and similar agencies help quite liberally here), but because they fail to reach a satisfactory entry standard academically (e.g. are relatively 'borderline' cases with only two 'A' Level passes). To increase the number of University openings, as things now stand in the world of Education, and to utilise those openings fully would mean that men of inadequate standard must be recruited. This, in turn, would result in a possible lowering of the standards demanded throughout a degree course, if such students are to obtain passes. In short, the value of degree work would be liable to be threatened. This we certainly do not think should occur. On the contrary, if anything, the standards should be raised.

Our experience is that the students just referred to make much better progress through an apprenticeship scheme in which they can read for the National Certificates and ultimately qualify for associate membership of the appropriate professional institutions."

E. "In my view it is unlikely that increased opportunities for further education will result in more boys of high calibre being able to enter universities or technical colleges for graduate work. It is probable that the limit of such people is already being reached. Many who would not formerly have gained entry to a university are now able to do so, and, because of the balance of the faculties in the universities, have to take an arts course. One result of this is that they are often lost to industry.

Generally speaking, an extension of the scientific and technological departments at undergraduate and postgraduate levels will probably mean that the increased numbers of students will have to come from those who would otherwise have gone into the arts side. If this is the case, the net effect would be that industry would obtain a higher proportion of people from the higher intelligence brackets but they would be graduates with the disadvantages outlined above. There would be little or no effect at the subprofessional level of employment, that is, the operative, the craftsman and the technician."

F. "No increase in the opportunities for further study at the Grammar Schools and Public Schools between Ordinary level and Advanced level of the General Certificate of Education is required. We would very strongly recommend that the number of places available at Universities for Engineering students is increased, both for undergraduate and post-graduate training, and that with this increase more facilities should be provided to enable the present expanding apprentice training schemes to send student apprentices to University, who have joined the firm's training scheme at the age of sixteen with a General Certificate of Education at Ordinary level.

In this connection it is also recommended that the increase in University facilities should be considered for both Sandwich Courses and for the normal degree courses based on full time study. This recommendation, if adopted, will create an increased demand for training at those technical colleges which are at present linked with apprentice training in industry. This movement is already noticeable and it is believed that the number of boys now being trained by local technical schools and colleges could be increased without serious difficulty.

It is recommended that the University authorities should keep clearly in mind the national demand for graduates, and some attempt should be made to ensure that the number of places provided in the various faculties are adjusted accordingly. Undoubtedly more places in Science and Technology are required but we

would suggest that, unless some readjustment is made in the relative numbers of students studying Science and Technology as compared with the Classics or Humanities, any substantial increase in the number of graduates now qualifying at our Universities can only be achieved by an increase in the number of students qualifying at pass degree standard."

VII. Shipbuilders

A. "We are finding that the biggest handicap, both in student apprentices and trade apprentices, regarding keeping them in the industry for which they have been trained, lies in the fact that the moment these young men finish their training they are called up under the National Service Acts, and whilst serving appear to lose their desire to return to the work for which they have been trained.

If it were possible to delay the call-up of these young men when they have completed their training by even one year, we feel very strongly that it would enable them to realise whilst serving that they would eventually be returning to the work for which they had been trained. This would give them greater incentive to carry on studying in their particular field of knowledge, so that when they had completed their time in the Armed Forces, they would be much more useful members of their various professions and trades.

As shipbuilders and engineers we have to try and keep remuneration on a basis competitive with world conditions, as otherwise we certainly will not continue to get export business. In the case of aircraft companies, where very high prices can be obtained for successful types of aircraft commercially, and any prices apparently for military types, the same conditions do not exist. During their national service training the young men naturally make wide contacts, and find that the aircraft and other light industries are more attractive to work in."

B. "In our particular engineering training we do not have a very large intake of University apprentices and prefer, where at all possible, they should have started their apprenticeship before going to the University. As you are probably aware, the Sandwich System of training has been followed for many years in the Scottish Universities and has given extremely satisfactory results. It is not our practice to allow a University graduate to commence training with us after graduation, although exceptions may be made in certain cases. As a consequence, the expansion of University facilities for technological students would only affect us as far as the number of entrants was concerned. It would not, in our opinion, advance the standard of education above that obtaining at the present time. It is unlikely that we would engage many graduates entering industry for the first time without experience."

C. "We do not require to employ many science graduates, because we do not carry out *directly* any original design or research work. This appears to be common practice in the Marine Engineering Industry, which relies on the various research bodies, which have been set up for that purpose, to keep the Industry abreast of current developments."

VIII. Motor Industry

A. "I have a feeling from observing the emergence of so many men from the chrysalis stage that so far as our particular industry is concerned (and this is the only one I know much about) none of the men who completed educational careers and came into industry at the age of, say, 23 or 24 ever seemed to catch up or pass the boys who started early. . . . It is clear that engineering graduates are already at a premium, and that a greater 'creaming off' for post-graduate research would accentuate this shortage. From our point of view the added university experience would not proportionally increase their value, due no doubt to the nature of our industry."

B. "Broadly speaking, it is true to say that our Training Committees, Directors and Executive incline strongly towards the man who has been developed in our Group after entry from Public, Grammar or Technical School, and who entered training either before or after National Service. Our general observations on graduates are that their success seems to depend more on the quality of the men than on the curriculum of the degree. Among many of the graduates we have seen, we have felt that they were not of the quality to benefit fully by University education, and our general opinion would be that too many, rather than too few, are 'creamed' off to the Universities. In this we must consider the total numbers entering the Universities to read technical, scientific, and all the non-technical subjects.

My own suggestion is that the first way to tackle the problem of increasing the availability of technologists and scientists to Industry is to correct the balance as between the numbers of those entering the Universities to read Arts and similar non-technical subjects, and those entering to read Scientific and Technical subjects.

In addition I feel we require—where the concentration of Industry warrants it—Institutions of a Technical College character specialising in advanced work rather than trying to carry this work alongside the somewhat elementary technical work with which the technician training is commenced."

C. "The increased facilities for further education already available to boys of good calibre, are affecting the general standard of those entering Industry as student apprentices, from our point of view any increase in these opportunities will undoubtedly aggravate the situation still further.

As well as affecting the standard of student apprentices entering Industry, difficulty is experienced in recruiting suitable students after taking their University Degrees. The present high demand for young men in this latter category would appear to be largely created by the intensive recruitment, of scientific graduates in particular, by various Government Departments.

It is felt that an important aspect in the training of potential key personnel for Industry, is, that they should be introduced to, and familiarised with, industrial conditions at shop floor level at an earlier age.

This background is then an influencing factor in their approach to, and conduct of, further educational studies. The normal University graduate coming into Industry is definitely handicapped by the lack of this background."

IX. A Civil Engineering Contractor

"Our experience is that graduates are able much more readily to qualify for membership of the Institution of Civil Engineers and, in general, we much prefer them, since the non-graduate student is very apt to pay more attention to matters of practical everyday construction, to the detriment of higher theoretical studies.

Consequently, we would consider that an extension of University facilities for technological students would be an advantage rather than otherwise."

APPENDIX II

EXTRACTS FROM LETTERS FROM THE NATIONALISED INDUSTRIES

National Coal Board

(a) Production Department (including technical management)

"It is important to bear in mind that, though we undoubtedly need greater numbers of highly-qualified specialist engineers than we now have, a considerable proportion of the people we recruit will continue to go into line management. In an industry so dominated by problems of industrial relations, it is more important that they should be good managers (which implies the possession of adequate technical qualifications) than that they should be first-rate technologists. Our problems are likely to be very different from, for instance, those of the aircraft industry.

On the question of the quality of graduates, it seems inevitable that the great expansion since the war in the pure and applied science departments of Universities should be accompanied by an increase in the proportion of graduates of quite ordinary calibre. Allowing for this, we are not displeased with the quality of the graduates we are getting, though we could wish that their training had not been so very narrowly technical. An important point here is that a large proportion of them are mining engineers and, since we are by far the biggest employers of mining engineers, the quality of graduates in mining depends to some extent on the ability of the N.C.B. to attract good people to enter its employment. Mining Engineering was unpopular before the war and the difficulties the industry has faced since nationalisation, combined with its rather unhappy history, have militated against us. Nevertheless, in place of 117 undergraduates in all Mining Departments before the war, there are now over 400.

(b) Scientific Department

We should have liked to recruit more graduates into Scientific Department than we have, because we have been and still are building up from small beginnings. The limit to our recruitment has been set by the rate at which good people become available to us. It is unlikely, however, when stability has been reached, that we shall be able to recruit as many people of the right type as we want, in view of the universal shortage. Generally speaking, most people who come into our scientific services are pure scientists, but chemical and other engineers are becoming increasingly important. Our chief difficulty has in fact been in the recruitment of research scientists. We are taking whatever steps we can to remedy this. In addition, we have found difficulty in finding good school leavers for the junior posts.

(c) Carbonisation Department

We also have a Carbonisation Department. At present, it is quite small and has comparatively few graduates. Its future, is under consideration. It may, or may not, expand considerably, both in size and quality. If it does expand, we shall need more first-class chemical engineers for it."

British Railways

"We have hitherto taken on some nine Arts etc. and some fifteen engineering graduates annually if suitable men are obtainable, but in consequence of the railway modernisation and equipment plans now being developed, we are desirous of obtaining many more engineering graduates, civil, mechanical and electrical. In practice, we can at present take on as many suitable engineering graduates as we can obtain. The reason why our full demand is not being satisfied is chiefly because demand for technological graduates exceeds supply

but partly also because some graduates offering themselves do not match up to our requirements or cannot pass a necessary medical test. Some, again, elect to do National Service immediately on graduation."

Central Electricity Authority

"Our requirement of university graduates with higher degrees is very small and refers, in the main, to our research branch. We are, however, unable to obtain all the first degree graduates with electrical or mechanical engineering qualifications that we require and we could well do with at least four times our present entry of 25 a year.

The quality of trainees passing through our graduate training scheme is, on the whole, suitable for the kind of positions they will be expected to fill as junior engineers and, after experience, for higher posts and we have no general complaints about their potentiality as leaders. We regard it as our responsibility to try by training and other methods to develop their qualities of leadership. We do notice, however, that many young men are coming on well in our student apprenticeship scheme and it is probable that many of them will progress as far in their careers as the graduates.

At the moment, we are not experiencing any difficulty in obtaining student apprentices. We have about 1,500 under training."

The Gas Council

"I took advantage of your enquiry to get the views of the Area Boards on the suggestion contained in your letter that the quality of engineering graduates has declined since the war, with special regard to their powers of leadership, initiative, etc. In most cases the Area Boards are of the opinion that they have little evidence of this, which may be accounted for by the very small number recruited and the very short time that they have been operating; one Board, however, does make the general observation that the quality of the good graduate recruits has not declined, but that owing to the increased numbers pursuing an engineering career, it is inevitable that those who are coming out of the lower end of the scale are of less good quality than previously."